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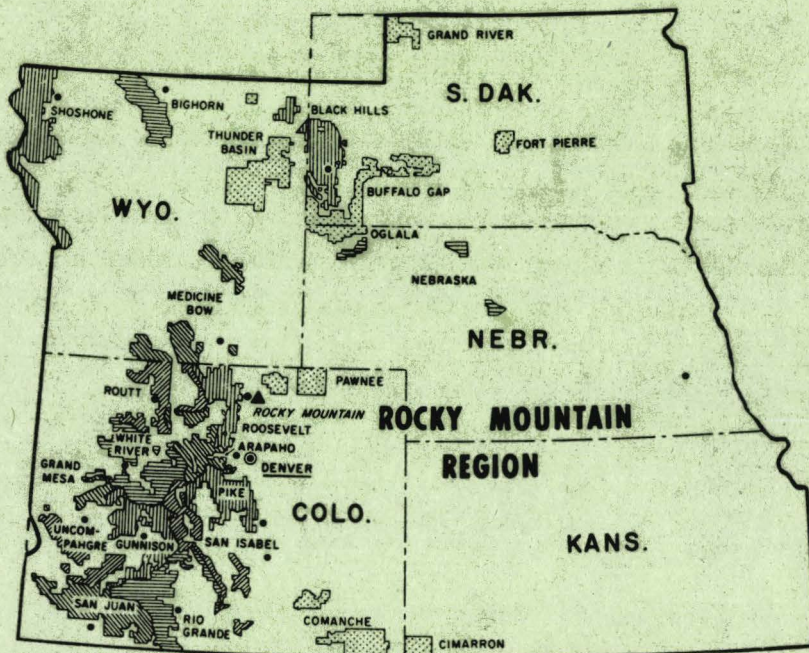
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BIOLOGICAL EVALUATION

POOR GROWTH AND MORTALITY OF LODGEPOLE PINE (PINUS CONTORTA DOUGL.) SEEDLINGS

Mount Sopris Nursery, White River National Forest



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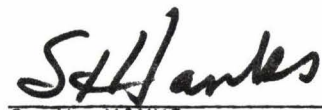
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POOR GROWTH AND MORTALITY OF LODGEPOLE PINE
(PINUS CONTORTA DOUGL.) SEEDLINGS
Mount Sopris Nursery, White River National Forest

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INTRODUCTION

Maintenance of adequate stocking in certain seedling beds has been a problem at the Mt. Sopris nursery for the past several years. This has been especially critical for lodgepole pine, and the magnitude of the problem varies with location in the nursery. Tom Landis, Forest Pathologist for the Forest Service, and Nagayoshi Oshima, Associate Professor of Forest Pathology at Colorado State University, initiated a study in the spring of 1974 to diagnose the cause of this poor seedling production.

METHODS AND PROCEDURES

Although sections of poor seedling growth were found in many of the nursery beds, one of the more serious problem areas was the east half of Unit 5 (Figure 1). This site was selected for intensive study, and the seedlings were examined for signs or symptoms of typical nursery diseases. In addition to these field observations, soil and seedling samples were collected for both pathogenic and chemical analysis. Samples were taken in April and October of 1974, at the beginning and end of the current growing season. These samples were taken in pairs, one from the poor growth area and one from a site with healthy seedlings. This procedure allowed some basis for comparison as no standards are available on the chemical status of seedlings on this particular site.

Fungal isolations and nematode extractions were performed on root and soil samples in the laboratory. Samples of the seedlings and soil were analyzed by independent laboratories to determine possible imbalances in the chemical composition.

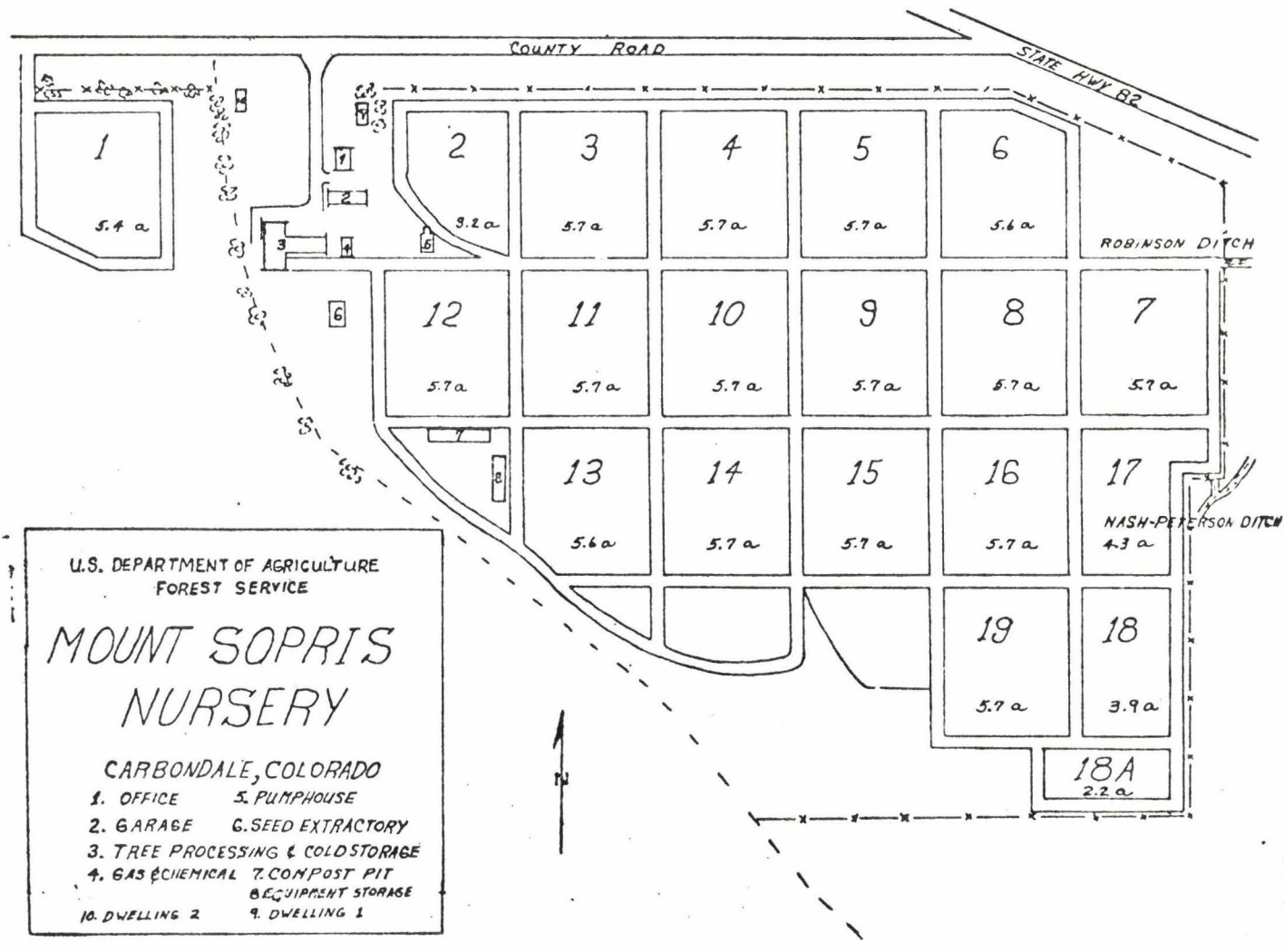


Figure 1 - Map of Mt. Sopris Nursery

RESULTS AND DISCUSSION

The general condition of the diseased pine seedlings was foliar chlorosis combined with stunting of the needles. The roots were small and undeveloped with a limited amount of branching. Stocking in the seedbeds was often greatly reduced, indicating a high degree of mortality (Figure 2).

Results of laboratory isolations indicated that biotic pathogens are not the primary cause of the poor seedling growth. Although the nematode extractions disclosed a small population of nematodes, they were not considered numerous enough to be significant. Fungal cultures revealed the presence of a seedling pathogen of the genus Fusarium; this fungus is normally present in soils to some degree. Although Fusarium may be partially responsible for the seedling problems, we feel that this fungus is acting as a secondary agent because of other predisposing factors.

Chemical analyses of the soil samples from the poor growth area revealed little differences from the good growth area with one notable exception. The seedbed with the problem seedlings showed over twice as much nitrate (NO_3) nitrogen as the soil sample from the control area. This difference is not in itself conclusive, however, because nitrate is required by plants in large quantities and is not directly toxic. Soil chemical analysis is often not sensitive enough because many nutrients which are present in the soil may not be available to the plants. Therefore, foliar analysis is often useful because the chemicals actually taken up by the plant can be determined.

Nutritional analyses of the healthy and unhealthy seedling foliage revealed some striking differences (Table 1). The April, 1974 samples were taken approximately one year after seeding. Several plant nutrients showed up in greater amounts in the diseased seedlings including nitrate, calcium, iron, and copper. These chemicals were decidedly more common, but many other plant nutrients are also higher in the unhealthy seedlings. Because no nutritional standards are available for lodgepole pine on this site, these values should be interpreted as relative.

The second set of foliage samples, taken in October, showed the same pattern of excess nutrients in the diseased trees (Table 1). Although several chemicals are in greater concentrations in the unhealthy seedlings, the extreme increase in the amount of nitrate nitrogen should



Figure 2 - Poor stocking and stunted, chlorotic seedlings in a lodgepole pine bed at Mt. Sopris Nursery.

TABLE 1

CHEMICAL ANALYSES OF LODGEPOLE PINE FOLIAGE
FROM MOUNT SOPRIS NURSERY, COLORADO

Sample Date	Seedling Condition	N-(NO3)	Plant Nutrients											
			P	K	Ca	Mg	Zn	Fe	Cu	Mn	S-(SO4)	Bo	Na	Cl
April, 1974	Poor	1.99	1750	3750	5625	2288	80	375	10	110	8.5	-	2.1	0.2
	Good	1.75	1750	4250	4000	1588	65	185	6	80	6.2		1.6	0.1
Notable Differences		*			*			*	*					

Analysis performed by Soils Testing Lab., Colorado State University.

October, 1974	Poor	0.059	0.18	0.88	1.30	0.26	425	1200	11	173	0.300	34	0.2	-
	Good	0.006	0.17	0.61	0.56	0.15	380	610	5	410	0.085	23	0.1	-
Notable Differences		*			*	*		*	*	*	*			

Analysis performed by Agricultural Consultants Lab., Brighton, Colorado.

Note: The units vary between samples and between nutrients and were, therefore, purposely omitted.

Actually, the units are irrelevant as only the comparisons are important.

be noted. The poorly developed seedlings contained almost 10 times as much nitrate as the control. Other nutrients were again more common in the injured seedlings with the one exception being manganese (Mn), which changed from a slight excess in the April test to a deficiency in the October test. Generally, though, most plant nutrients are in greater concentrations in the diseased seedlings.

The results of the pathological and chemical tests indicate that there is no simple explanation for the seedling decline, but rather that a biological-chemical complex is responsible. The great excess of nitrate in the seedling foliage would seem to indicate chemical toxicity. Nitrate is not directly toxic to plants, however, although other forms of soil nitrogen may be. Even though the high nitrate level is not directly responsible for the diseased seedlings, it is a symptom of other factors that can be damaging.

This nitrate level is probably a reflection of fertilization treatments applied during the 1974 growing season (Table 2). These ammonium nitrate applications were performed to alleviate the chlorotic condition of the lodgepole pine seedlings that had appeared that spring. Because chlorosis is often a symptom of nitrogen deficiency, this would be a logical treatment. But the soil was already high in nitrate, as evidenced by the April tests, so these applications greatly increased the nitrogen level of the soil. This condition was probably responsible for several secondary effects which in turn caused the seedling problems.

One possible effect of the ammonium nitrate fertilization could have been nitrite (NO_2) accumulation in the soil; this form of nitrogen is extremely toxic to plants. Nitrite results from the microbial oxidation of ammonium (NH_4) in the soil solution and is itself oxidized to nitrate. The three applications of ammonium nitrate added to a soil already high in nitrate may have induced accumulation of the toxic nitrite ion.

High soil nitrate levels may indirectly influence plant growth by causing a biochemical imbalance in the soil-plant environment. Nitrate is rapidly taken up by the plant root system and is normally converted into an organic nitrogen form before it can be translocated to the rest of the plant. To do this conversion, the root requires photosynthate from the shoot for both the energy and the organic combining molecule. Under conditions of high soil nitrate, this conversion process may actually be outcompeting other vital plant processes for this photosynthate. The fact that unconverted nitrate was present in the foliage

TABLE 2

TIMETABLE OF CHEMICAL TREATMENTS
APPLIED TO BLOCK 5, UNIT 9
OF MOUNT SOPRIS NURSERY

<u>Timetable</u>	<u>Seedling Condition</u>	<u>Soil Treatments (Per Acre)</u>
April, 1973	Before seeding	50# Ammonium sulfate
	Seeding	
	Seedling emergence	
June, 1973		100# Ammonium sulfate
August, 1973		100# Urea
End of first growing season - seedlings appeared normal		
Beginning of second season - seedlings began to show chlorosis		
May, 1974	Poor	100# Ammonium nitrate
June, 1974	Poor	100# Ammonium nitrate
July, 1974	Poor	100# Ammonium nitrate
Other treatments		
1. To increase the organic matter level of the soil, 75 cu. yds. per acre of peat were applied annually.		
2. To inhibit weed germination a herbicide called Dymid 80W was applied once a month during the growing season at a rate of 6# per acre.		

indicates that the plant root system could not handle the concentrations present in the rhizosphere. Thus, high soil nitrate could be at least partially responsible for the chlorotic condition of the pine seedlings.

High levels of nitrogen can also cause an imbalance in the critical carbon-to-nitrogen ratio (C:N) in the soil. This condition is entirely possible because the Mt. Sopris soils are already low in carbon because of the inherent low organic matter level. A beneficial C:N ratio is usually considered to be approximately 10:1, which shows the high carbon level necessary for fertile soils. High levels of nitrogen fertilizer and the inherently low carbon in the soil could logically cause the C:N ratio to be unbalanced on the nitrogen side.

A poor C:N can favor several pathogenic soil fungi such as Fusarium spp.; these fungi are normally present in the soil, but are normally outcompeted for sites by more beneficial fungi. When the nitrogen level rises these pathogens could become more prevalent and infect tree seedlings. The confirmed isolation of Fusarium from the nursery soil substantiates this possibility.

High nitrogen levels may also have a deleterious effect on the establishment and growth of mycorrhizae on seedling roots. These symbiotic fungi are necessary for good seedling survival and growth, especially in outplantings. These fungi usually exist as saprophytes on soil organic matter which they require for an energy source. A poor C:N may lower the base populations of these beneficial fungi and hence adversely affect seedling vigor.

CONCLUSIONS AND RECOMMENDATIONS

By now it should be apparent that the problem of poor seedling growth and survival is very complex, and, as such, will have no simple solution. Due to the fact that the problem is most closely related to soil chemical status, our recommendations will mainly consist of an overall program of soil management. To implement this program, each block of the nursery should be treated as a management unit, and treatments should be directed towards bringing that unit to optimal conditions for a coniferous tree nursery.

Soil organic matter should be encouraged as much as possible to improve the poor C:N ratio. One of the most efficient ways of increasing the soil humus level is through alternate cropping. Barley is a

good species to use in this respect because, as well as increasing organic matter, barley has been found to be inhibitory to soil pathogenic fungi. A good C:N could be encouraged by growing two crops simultaneously for green manure purposes. Legumes grown with a hay crop would be beneficial because the legumes would furnish nitrogen, whereas the hay would provide good organic matter. Alternating pine crops with green manure species could, therefore, provide multiple benefits.

The relatively high pH is a continuing problem at Mt. Sopris Nursery; the inherently high pH values should be reduced to the optimal range of 5.0-6.0. Many soil diseases are favored by higher pH values and the availability of plant nutrients is often reduced. Current treatments used at Mt. Sopris should be continued and new alternatives explored in order to reduce the pH to an optimal level for coniferous seedlings.

Mycorrhizal fungi should be encouraged in all of the nursery beds. These fungi serve to protect the seedling root system against disease organisms as well as aid in nutrient uptake. Field inoculation with litter from an established healthy forest stand can effectively introduce the proper mycorrhizal species into the beds. However, when this method is used to inoculate the nursery soil, care must be taken to prevent introducing dangerous pathogens or other diseases. Mixing this coniferous litter with the nursery soil will have the additional benefit of lowering the soil pH. The additional organic matter provided by the green manuring should serve as a reserve energy source for the mycorrhizal fungi once they are established. Additional mycorrhizal studies are planned by the Forest Pest Management Staff.

Fertilizers or any other chemical additive should not be applied on the basis of seedling symptoms alone or merely as a matter of policy. In this regard, regular foliage samples should be collected and analyzed at the beginning of each growing season. A nutrient deficiency could then be properly corrected without the danger of upsetting the balance of the plant-soil chemical system. It would also be beneficial if irrigation water suitability tests could be conducted so that all chemicals being added to the soil system could be monitored.

Units with recurring poor production should be temporarily taken out of conifer seedling culture; these problem areas should be treated on an individual case basis. Extensive tests should be conducted, and treatments designed to correct the problem before replanting with tree seed.

Species such as ponderosa pine (P. ponderosa Lows.) which apparently grow without special problems, should be encouraged at the nursery.

We feel that an overall soil management program such as this will yield substantial benefits for meeting the goals of the Mt. Sopris nursery and at the same time, reduce the incidence of serious problems.